Software workflows and tools for integrating remote sensing and organismal occurrence data streams to assess and monitor biodiversity change

Completed Technology Project (2017 - 2019)

Project Introduction

Remote sensing combined with rapidly growing types and amounts of in situ spatiotemporal biodiversity data now enable an unrivaled opportunity for planetary scale monitoring of biodiversity change. However, i) the breadth of remote-sensing data streams of different spectral and spatiotemporal nature, ii) the heterogeneity of spatial biodiversity data types, including individual movement GPS tracks, survey- or sensor-based inventories, and vast citizen science observations, and iii) the spatial and temporal scale-dependence of biodiversity change and its detection, all necessitate versatile technology capable of complex data fusion. This need is further exacerbated by ongoing growth of data that requires highly scalable visualization and analysis solutions. No general solution currently exists. The objective of the proposed work is to fill this gap with dedicated open-source software workflows and tools to the benefit of both remote sensing and biodiversity change communities. The proposed work will build on earlier developments of global remote-sensing supported climate and environmental layers for biodiversity assessment and develop a general workflow that allows the environmental annotation, visualization, and change assessment for past and future spatial biodiversity occurrence data. Observed, in-situ biodiversity has intrinsic spatiotemporal grain and associated uncertainty based on observation methodology and data collection. Likewise, remotely sensed environmental data also vary in spatiotemporal grain from meters to kilometers. This project will develop technical infrastructure and software workflows to easily develop and serve appropriate summaries of environmental data for biodiversity observations. For example, a list of migrating birds observed from one location one afternoon would require a different summary of environmental data compared to a list of vascular plants known to exist in a 100km2 protected area. We will develop algorithms that automate appropriate summaries of relevant environmental data to characterize the spatiotemporal environmental context of the in-situ biodiversity observation. Furthermore, this system will draw from near-real time collection of RS and RS-derived environmental data (such as land surface temperature, precipitation, and vegetation indices) to enable both historical and near real-time annotation of continuously updating biodiversity data streams. Our scalable system will be capable of fusing large spatial biodiversity data available through Map of Life (https://mol.org), including data assets from GBIF (http://www.gbif.org, >700M records), public Movebank GPS tracking records (https://www.movebank.org, ~20M records), and other incidental and inventory datasets (~100M records). The generalized software workflows and tools will enable characterization and comparison of environmental associations of individuals, populations or species over time, globally. This will allow the quantification of observed environmental niches as well as the detection of change through time in both environmental associations and geographic distributions of biodiversity. Our proposal addresses the ROSES A.41 solicitation dramatically improving the ease with which the biology and ecology communities can understand, select and use

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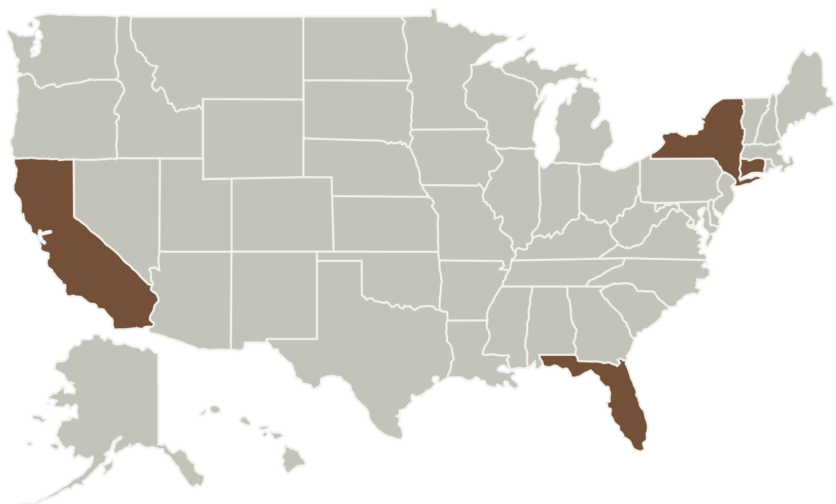
appropriately NASA remote sensing data." And the planned workflows will provide some "automated analytic techniques to scale the use of all relevant observational data in the understanding of patterns and processes in biodiversity" as well as "tools which aid the researcher in formulating and evaluating hypotheses quickly." The proposed work will address the biodiversity aspect of the overarching science goal of the NASA CC&E focus area "Detect and predict changes in Earth's ecosystems and biogeochemical cycles, including land cover, biological diversity, and the global carbon cycle." The planned entry TRL for this project is 2-3 and the exit is aimed at TRL 5-6."

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Yale University	Lead Organization	Academia	New Haven, Connecticut

Primary U.S. Work Locations	
California	Connecticut
Florida	New York

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

Yale University

Responsible Program:

Advanced Information Systems Technology

Project Management

Program Director:

Pamela S Millar

Program Manager:

Jacqueline J Le Moigne

Principal Investigator:

Walter Jetz

Co-Investigators:

Robert P Guralnick
David Thau
Tim Robertson
Dirk N Karger
Adrienne Marable
Martin C Wikelski
Donald G Hobern
Adam Wilson

Technology Maturity (TRL)

Start: **3**
Current: **3**

1 2 **3** 4 5 6 7 8 9

Applied Research | Development | Demo & Test

Technology Areas

Primary:

- TX08 Sensors and Instruments
  └ TX08.3 In-Situ Instruments and Sensors
    └ TX08.3.4 Environment Sensors

Target Destination

Earth